# MO-160

## MODULADOR COFDM DVB-T

## *DVB-T COFDM MODULATOR*



PROMAX

# NOTAS SOBRE SEGURIDAD

**Antes de manipular el equipo leer el manual de instrucciones y muy especialmente el apartado PRESCRIPCIONES DE SEGURIDAD.**

**El símbolo  sobre el equipo significa "CONSULTAR EL MANUAL DE INSTRUCCIONES". En este manual puede aparecer también como símbolo de advertencia o precaución.**

**Recuadros de ADVERTENCIAS Y PRECAUCIONES pueden aparecer a lo largo de este manual para evitar riesgos de accidentes a personas o daños al equipo u otras propiedades.**

# *SAFETY NOTES*

***Read the user's manual before using the equipment, mainly " SAFETY RULES " paragraph.***

***The symbol  on the equipment means "SEE USER'S MANUAL". In this manual may also appear as a Caution or Warning symbol.***

***Warning and Caution statements may appear in this manual to avoid injury hazard or damage to this product or other property.***

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APPENDIX A: Channel Plans

English

# *DVB-T COFDM MODULATOR*
# MO-160

## 1 GENERAL

### 1.1 General description

The **MO-160** is a DVB-T modulator fully compliant with the standard **ETSI EN 300 744 v1.5.1**. The modulator input is an **MPEG-2** transport stream (**TS**) in **DVB-SPI** or **DVB-ASI** format. The outputs are **DVB-T** signals **COFDM**-modulated and up converted to **IF** and **RF**.

The **MO-160** supports **2k** and **8k** modes, as well as **hierarchical** transmission, and it could be used in **Multi Frequency Networks** (**MFN**). Digital coding and modulation are implemented by means of programmable logic devices using intellectual property developed by PROMAX. This makes the design highly flexible, allowing to tailor it to any particular application, and offering plenty of features at low cost.

Highlights of this product are:

- 2k and 8k mode operation.
- Hierarchical modes.
- Master and Slave mode operation.
- Channel bandwidth of 6, 7 and 8 MHz (user selectable).
- High frequency resolution (in steps of 1 Hz).
- High MER.

English

[1] *Trade Mark of the DVB Digital Video Broadcasting Project (5363).*

## 1.2 Functional description

The **MO-160** is a general purpose **DVB-T modulator** contained in a 19" 1U chassis. The unit has three selectable **MPEG-2 TS** inputs (two serial **ASI** inputs and one parallel **SPI** input). Either of these inputs can be used to modulate the **COFDM** signal in both **hierarchical** (one **TS** input) and **non-hierarchical** (two **TS** inputs) modes. An additional **test TS** can be generated internally in the modulator. This allows to generate compliant **DVB-T** signals even in the absence of a valid **TS** input.

In ***slave*** mode, the useful bit rate at the **TS** input to the **COFDM** modulator has to be the one defined in **ETSI EN 300 744** for each choice of **DVB-T** transmission parameters. The modulator automatically synchronises its internal clock to the incoming **TS** packet rate. The ***slave*** mode allows to use one **TS** input with constant bit rate in non-hierarchical modes. When using hierarchy, the user has to choose which **TS** (**HP** or **LP**) the selected **TS** input is mapped to. This is the stream the modulator actually synchronises to. The other hierarchical **TS** is generated internally as a **PRBS** test sequence.

The input bit rate in slave mode should be within 0.1‰ of the values specified in the **DVB-T** standard (See section "*4.10 DVB-T useful bit rates*") and approximately constant. This operating mode is useful when re-modulating an off-air **DVB-T** signal with the same parameters without the need to demultiplex and re-multiplex the transport stream (as it would be the case in master mode).

The lock-in range of the **MO-160** with respect to the **TS** rate is typically greater than that of a **COFDM** demodulator. It's thus possible that the modulator is perfectly synchronised in slave mode and, however, a **DVB-T** receiver is unable to acquire sync.

In ***master*** mode, the **MO-160** is able to work with any incoming bit rate as long as this is strictly lower than the value given in the **DVB-T** specification for the modulation parameters in use (See section '*4.10 DVB-T useful code rates*'). The input **TS** bit rate is adapted (bit rate adaptation) to the useful bit rate required by the **DVB-T** signal by stuffing the **TS** with NULL packets (packet stuffing). This stuffing process alters the sequence of PCR values embedded in the **TS**. These values have to be re-stamped for the resultant PCR jitter to remain within the limits specified by the **DVB**. In hierarchical modes, operating the **MO-160** as master has the added advantage over the slave mode of being able to use any of the three **TS** inputs as the **HP** input, **LP** input or both.

Whenever possible, it is advised to use an input bit rate considerably lower than the nominal value given in the **DVB-T** specification. Otherwise, an input rate too close to the required value might eventually lead to overflow of the **TS** packet buffer implemented in the modulator.

The modulator can be configured to generate any of the transmission modes listed in the **DVB-T** specification. In hierarchical modes, the **HP** and **LP** streams can be encoded with different convolution code rates. The channel bandwidth can be set by the user to 6, 7 or 8 MHz as required by the application. Several test modes are available in the **MO-160** (blanking of carriers, single tone output, test **TS** generation, **CBER** and **VBER** injection).

The modulator is frequency agile. The user can select an **RF** output frequency between 470 and 875 MHz in steps of 1 Hz. In normal operation, the **IF** output frequency is internally set by the modulator and varies between 32 and 36 MHz depending on the selected **RF** frequency. The **RF** output can be switched off, in which case the **IF** frequency is fixed at 36 MHz. The polarity of the **IF/RF** spectrum (inverted or non-inverted) can be selected by the user.

The **MO-160** has been designed to work in Multi Frequency Networks (**MFN**). Single Frequency Network (**SFN**) operation is not currently supported. The quality of the output signal has been optimised for 8 MHz channels. The **MER** measured at **IF** in this case is approximately 40 dB in master mode.

The operation of the **MO-160** is done via the front panel LCD display and controls. The modulator can be easily configured by navigating through a rather intuitive set of menus. A couple of LEDs located on the front panel signal the existence of errors in the modulator or whether the equipment is properly powered.

## 1.3 Specifications

**INPUTS**

| | |
|---|---|
| **MPEG-2 Transport Stream** | Two DVB-ASI inputs, 75 Ω female BNC One DVB-SPI input, LVDS DB-25 TS packets of length 188 or 204 bytes (automatic detection). Support for burst and continuous packet mode. |
| **Operating modes** | |
| **Master** | Input TS bit rate strictly below the value given in the DVB-T specification Packet stuffing for bit rate adaptation and PCR re-stamping are carried out automatically |
| **Slave** | Input TS bit rate constant and equal to the value given in the DVB-T document (no stuffing). Tolerance ±0.1‰. |

**IF OUTPUT**

| | |
|---|---|
| **Type** | 50 Ω BNC female connector. |
| **Frequency range** | Variable between 32 and 36 MHz in steps of 1 Hz; fixed at 36 MHz when RF output is off. |
| **Spectrum polarity** | Selectable via front panel controls. |
| **Power level (average)** | 0 dBm (107 dBμV) fixed. |
| **In-band amplitude ripple** | < 0.5 dB. |
| **In-band group delay ripple** | <10 ns. |
| **Frequency stability** | 20 ppm. |
| **Out-of-band spectral characteristics**[2] | |
| **@ ± 3.805 MHz** | 0 dBc. |
| **@ ± 4.25 MHz** | -39 dBc (2k), -47 dBc (8k). |
| **@ ± 5.25 MHz** | -52 dBc. |
| **Level of harmonics and spurious** | ≤ -50 dBc. |
| **MER**[3] | > 40 dB. |

[2] Frequencies are referred to the central frequency for an 8 MHz channel. Peak levels measured using a 10 kHz bandwidth are referred to the carriers located on either side of the spectrum. Values shown are the worst case and correspond to guard intervals of 1/32.

[3] Value measured in master mode. In slave mode, the MER is greater than 38 dB for 8 MHz channels, and around 35 dB for 7 and 6 MHz.

**RF OUTPUT**

| | |
|---|---|
| **Type** | 50 Ω N-type female connector. |
| **Frequency range** | Adjustable between 470 and 875 MHz in 1 Hz steps. |
| **Spectrum polarity** | Selectable via front panel controls. |
| **Power level (average)** | Approximately 90 dBμV (not calibrated) with no attenuation.<br>Variable attenuation of 0 to 25 dB in 32 steps (not calibrated) dB. |
| **Frequency stability** | 10 ppm. |
| **MER** | > 36 dB. |
| **SPURIOUS** | < 35 dBc. |

**DVB-T PARAMETERS**

| | |
|---|---|
| **IFFT size** | 2k, 8k. |
| **Guard intervals** | 1/4, 1/8, 1/16, 1/32. |
| **Code rates** | 1/2, 2/3, 3/4, 5/6, 7/8. |
| **Constellations** | QPSK, 16QAM, 64QAM. |
| **Hierarchical modes** | 16QAM and 64QAM constellations with constellation ratio $\alpha$= 1, 2 or 4. |
| **MFN operation** | Available. |
| **Channel bandwidth** | 6, 7 and 8 MHz (user selectable). |

**TEST MODES**

| | |
|---|---|
| **Carrier blanking** | Blank a number of carriers (start index to stop index) within the COFDM ensemble. This allows to measure in-band intermodulation and quantisation noise. |
| **Pilot carriers** | Generate the pilot carriers only (continual and TPS). |
| **Single carrier** | Generate a single carrier at the channel central frequency whose level equals the average COFDM output power or is set to the maximum available. This is intended for signal level alignment. |
| **TS packet generation** | Internal generation of test TS using PRBS sequences of length 15 or 23 embedded within NULL packets as specified in document ETSI TR 101 290. |
| **PRBS generation** | Map a PRBS sequence into constellation points following the guidelines of document ETSI TR 101 290. |
| **Bit error injection** | Inject bit errors at the input to the constellation mapper (results in a non-zero CBER before the Viterbi decoder) or at the input to the convolutional encoder (results in a non-zero VBER after the Viterbi decoder). |

English

**RS-232C INTERFACE**

**POWER SUPPLY**

| | |
|---|---|
| **Voltage** | 90 - 250 VAC. |
| **Frequency** | 50 - 60 Hz. |
| **Consumption** | 20W. |

**OPERATING ENVIRONMENTAL CONDITIONS**

| | |
|---|---|
| **Indoor use** | |
| **Altitude** | Up to 2000 m. |
| **Temperature range** | From 5°C to 40°C. |
| **Max. relative humidity** | 80 % (up to 31°C), decreasing lineally up to 50% at 40 °C. |

**MECHANICAL FEATURES**

| | |
|---|---|
| **Dimensions** | 482 (W.) x 44 (H.) x 381 (D.) |
| **Weight** | 6.3 kg. |

**OPTIONS**

**OP-160-P** 10 dBm amplifier.

**RECOMMENDATIONS ABOUT THE PACKING**

It is recommended to keep all the packing material in order to return the equipment, if necessary, to the Technical Service.

# 2 SAFETY RULES

## 2.1 General safety rules

* **The safety could not be assured if the instructions for use are not closely followed.**

* Use this equipment connected **only to systems with their negative of measurement connected to ground potential**.

* This is a **class I** equipment, for safety reasons plug it to a supply line with the corresponding **ground terminal**

* This equipment can be used in **Overvoltage Category II** installations and **Pollution Degree 1** environments.

* When using some of the following accessories **use only the specified ones** to ensure safety.

  Power cord CA005

* Observe all **specified ratings** both of supply and measurement.

* Remember that voltages higher than **70 V DC** or **33 V AC rms** are dangerous.

* Use this instrument under the **specified environmental conditions**.

* **The user is only authorized to** carry out the following maintenance operations:

  Replace the fuses of the **specified type and value.**

  On the Maintenance paragraph the proper instructions are given.

  Any other change on the equipment should be carried out by qualified personnel.

* **The negative of measurement** is at ground potential.

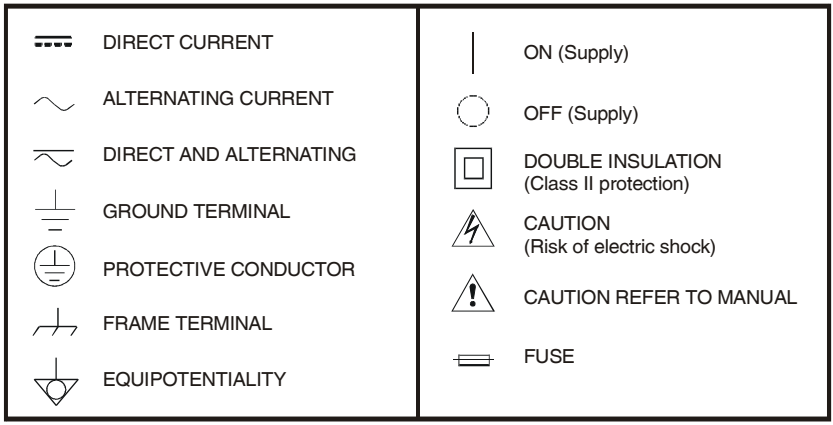
* **Do not obstruct the ventilation system** of the instrument.

* Use for the signal inputs/outputs, specially when working with high levels, appropriate low radiation cables.

* Follow the **cleaning instructions** described in the Maintenance paragraph.

English

* Symbols related with safety:




## 2.2 Descriptive Examples of Over-Voltage Categories

**Cat I** Low voltage installations isolated from the mains

**Cat II** Portable domestic installations

**Cat III** Fixed domestic installations

**Cat IV** Industrial installations

# 3 INSTALLATION

## 3.1 Power Supply

The **MO-160** is an equipment powered through the mains for its operation.

### 3.1.1 Operation using the Mains

Connect the instrument to the mains through the AC voltage connector [12] located on the **MO-160** rear panel.

Check if the mains voltage is according to the equipment specifications.

## 3.2 Installation and Start-up

The **MO-160** modulator is designed for use as a rack-mounted 19 inches device (1U chassis).

Switch the main switch [13] located in the rear panel to position I (power on). After a successfully start up, the equipment emits four acoustic tones to indicate that it is ready to begin operation. When the equipment is connected to the mains, the green LED **LINE** [3] remains lit.

# 4 OPERATING INSTRUCTIONS

***WARNING:***

*The following described functions could be modified based on software updates of the equipment, carried out after manufacturing and the publication of this manual.*

## 4.1 Front panel description

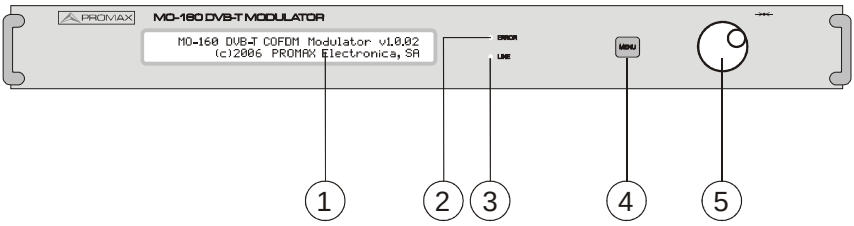



**Figure 1.-** Front panel.

**[1] LCD display**
With 2x40 characters crisply clear due to its white LED backlight.

**[2] ERROR**
RED LED has a couple of functions. For each operating second, the first tenth of that second indicates whether there are sync problems in the modulator (ON) or not (OFF). Examples are loss of TS sync or invalid input bit rates.

The remaining nine tenths of a second, the RED LED shows whether errors lasting more than 5 seconds (since the last time the error counter was cleared) are detected (ON).

**[3] LINE**
A GREEN LED indicator shows when the power supply is **ON**.

**[4] MENU**
The **MENU** key allows the user to enter and exit the menu functions, and to modify the equipment functional parameters (modulation parameters, output frequency and level, and other configuration and setup functions).

English

**[5] Rotary encoder button**.
This has many different functions: Moving across the different display menus and sub-menus, and validating selected options.

When the rotary encoder is pressed, and we are modifying any equipment function, the option currently being shown on the LCD panel is selected. Turning the encoder clockwise (CW) or counter clockwise (CCW) allows us to navigate through each menu function and option available in the **MO-160**.

## 4.2 Rear panel description

The rear panel shows, from right to left, the mains socket for AC voltage input, the fan air outlet, a DB-9 connector for remote control via an RS-232C COM port, a parallel DVB-SPI TS input, two DVB-ASI TS inputs, an IF (nominally 36 MHz) test output and the main RF output, at the frequency and level chosen by the user.

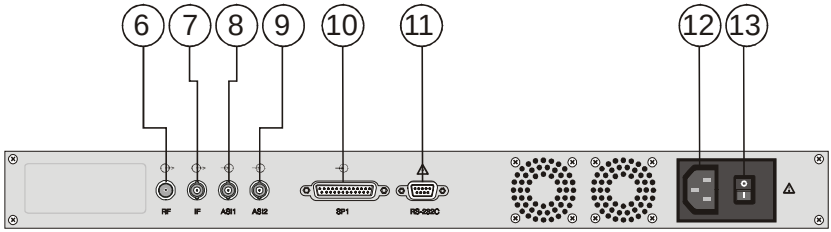



**Figure 2.-** Rear panel view.

**[6] RF output, 50Ω, female N-type connector.**

**[7] IF output, 50Ω, female BNC.**

**[8] ASI1 input, 75Ω, female BNC.**
DVB-ASI input number 1.

**[9] ASI2 input, 75Ω, female BNC.**
DVB-ASI input number 2.

**[10] Parallel TS input, DB-25**
DVB-SPI input.

**[11] RS-232C connector, DB-9**
DB-9 connector for remote control via an RS-232C COM port.

**[12] AC voltage connector**
Supplies power to the equipment.

**[13] Mains switch**
Switch on or off the power supply.

**NOTE:** The actual IF frequency value varies between 32 and 36 MHz, depending on the RF frequency. When a fixed 36 MHz is needed, the RF output of the modulator has to be disabled in the RF menu.

## 4.3 Menu functions

After start up, the equipment display shows information regarding the main operating conditions, as can be seen in the following example:

**FREQ: 650000000 Hz ATT: 10 dB**
**FFT:8K CONST:64QAM BW:8 MHz GUARD:1/4**

**FREQ: 650000000 Hz ATT: 10 dB**
**TEST: NONE TS: Master (204)**

Here the RF frequency is 650 MHz, the 1-dB step RF attenuator is set to 10 dB, the DVB-T signal has 8K carriers, occupies 8 MHz and uses a 64 QAM constellation with a guard interval of ¼. No test mode is selected (NONE) and the operation mode of the MO-160 is set to master. Packets of length 204 bytes are currently being detected on the TS input selected by the user.

After a few seconds, the display changes its contents to show the working time and error count information, as follows:

**MO-160 PROMAX ELECTRONICA, S.A.**
**Working: 01:13:55 ERR: 0**

The text on the upper line (the name of the company, in the example above) could be customised via the RS232 port to the user's needs, allowing for an easy identification of the equipment or for some piece of advice.

Pressing the MENU key, allows us to enter the main menu level. Pressing MENU again, takes us to the main status display. This main menu level uses the first text line to give some advice on the operation assigned to each control, and the second line to display the selectable options and functions.

**MENU: back PUSH: select TURN: next/prev.**
**MODULATOR**

English

Turning the encoder CW or CCW, cycles through the submenu titles:

1. MODULATOR
2. RF
3. LEVEL
4. TEST
5. CONFIGURATION

## 4.4 MODULATOR functions.

At this menu level, the modulator parameters can be modified and customised to the user's needs. When modifying any modulation parameter, changes became active only when confirmed by pressing the encoder function. Instead, pressing the MENU key allows us to cancel the change of option. Let's comment on each function.

- **HP TS Input**: Selects the input used for providing a High Priority (HP) Transport Stream (TS) to the COFDM modulator. Note that in non-hierarchical transmissions, this is the only TS input to the modulator. Options are:

  ASI1: Use TS provided at ASI1 input connector (rear panel).
  ASI2: Use TS provided at ASI2 input connector (rear panel).
  SPI: Use parallel TS provided by SPI connector (rear panel).
  PRBS: Use internally generated PRBS data to generate TS test packets.

- **LP TS Input**: Selects the input used for providing a Low Priority (LP) Transport Stream (TS) to the COFDM modulator. Note that in non-hierarchical transmissions, this input is not used. Options are:

  ASI1: Use TS provided at ASI1 input connector (rear panel).
  ASI2: Use TS provided at ASI2 input connector (rear panel).
  SPI: Use parallel TS provided by SPI connector (rear panel).
  PRBS: Use internally generated PRBS data to generate TS test packets.

- **BW**: This option enables output channel bandwidth selection. The COFDM signal can be generated with a BW of 6 MHz, 7 MHz and 8 MHz.

  8 MHz: selects an 8 MHz bandwidth.
  7 MHz: selects a 7 MHz bandwidth.
  6 MHz: selects a 6 MHz bandwidth.

- **Hierarchy**: Using this function the COFDM modulator is switched between hierarchical mode, with different alpha constellation ratios, and non-hierarchical mode operation. The options available are:

  OFF: non-hierarchical operation.
  a=1: hierarchical mode with alpha = 1.
  a=2: hierarchical mode with alpha = 2.
  a=4: hierarchical mode with alpha = 4.

- **HP Code Rate**: Using this function, the user can modify the convolutional code rate for the High Priority (HP) Transport Stream (TS). The available options are as follows:

  1/2
  2/3
  3/4
  5/6
  7/8

- **LP Code Rate:** Using this function, the user can modify the convolutional code rate for the Low Priority (LP) Transport Stream (TS). The available options are as follows:

  1/2
  2/3
  3/4
  5/6
  7/8

- **Constellation**: Here the menu allows the selection of one of the available constellations. The options are:

  QPSK
  16QAM
  64QAM

- **Guard Interval**: This function selects the required guard interval for the COFDM signal. The available values are:

  1/4
  1/8
  1/16
  1/32

English

- **FFT Mode**: Selection of the required FFT value (number of carriers in the COFDM ensemble). The modulator has these options:

  2K

  8K

- **Spectral Inversion**: This function allows inversion of the spectrum generated in IF and RF. As the IF spectrum is by itself inverted compared to the RF output, the inversion applied is related to the RF output. The possible options are:

  OFF: Carriers with lower indices occupy the lower frequencies of the RF channel.

  ON: Carriers with higher indices occupy the lower frequencies of the RF channel.

- **PRBS bits**: Selection of the length in bits of the internally generated pseudorandom sequences:

  23: PRBS sequences of length $2^{23}$-1 as documented in TR 101 290.

  15: PRBS sequences of length $2^{15}$-1 as documented in TR 101 290.

- **TS sync mode**: Selects the mode of operation of the modulator with respect to the incoming TS (see section 1.2 for further details):

  Master

  Slave

- **Slave mode TS lock**: In slave mode, this selects the TS input to which the modulator locks its internal clock. Options are:

  HP: The modulator is synchronised with the HP TS.

  LP: The modulator is synchronised with the LP TS (hierarchical modes only).

- **Test Opt:** Selects the test to be carried out. Available options are:

  **NONE:** Normal COFDM output.

  **CBER:** Inject channel bit errors to obtain a non-zero BER before the Viterbi decoder (Channel BER).

  **VBER:** Inject bit errors to obtain a non-zero BER after the Viterbi decoder (Viterbi BER or simply BER).

  **Blank carriers:** Blank carriers starting at index Start Carrier and ending at index Stop Carrier (see section "*4.7 TEST parameters*").

  **Pilots only:** Generate a DVB-T signal containing pilot carriers only (continual and TPS).

  **PRBS/ TR 290:** Replace the input to the constellation mapper with a PRBS sequence of length $2^{15}$-1 or $2^{23}$-1 (see PBRS bits entry above) as specified in document ETSI TR 101 290.



## 4.5 RF functions.

The selection of this item allows us to access those functions related to the RF output. Let's review each option.

- **Frequency**: This function allows the selection of the RF frequency. Changes made by turning the rotary encoder are applied directly to the output, allowing for a smooth tuning of the output frequency.

When entering this function, the display shows the current frequency and the step used to modify it, if the encoder is turned. Frequency increments are positive when turning CW and negative if CCW. The LCD panel looks as follows:

**MENU: back PUSH: select TURN: next/prev.**
**RF Frequency: 650000000 Hz <10MHz>**

In this case, the current output frequency is 650 MHz and turning CW one notch (each notch is marked by an audible tone) will change that value to 660 MHz.

In this situation, each time we press the encoder button, the frequency step will be modified to 1 MHz, 100 kHz, 10 kHz, 1 kHz, 100 Hz, 10 Hz, 1 Hz and again to 10 MHz, allowing a cyclic selection of the desired step value.

To quit this function, the MENU key must be pressed.

- **Channel**: Using the set of channel tables included in the **MO-160** makes the output frequency tuning faster. This allows direct selection of standard frequencies used in most countries.

Entering this function, a list of all available channels is displayed sequentially. Turning the encoder will lead us to the desired one. Pushing the encoder selection key will exit that function.

The channel list is taken from a set of channel plans loaded into the equipment. The available channel plans are displayed and selected from the CONFIGURATION menu, as we'll see later.

Also in this case, frequency changes are applied immediately to the RF stage, allowing an interactive frequency adjustment.

The list of channel plans can be found in Appendix A.

- **Disable**: This option is to disable the RF output. At the same time, the IF frequency is tuned to a nominal value of 36 MHz. The selectable values are:

  NO.
  YES.

## 4.6 LEVEL functions

This menu item collects the functions related to RF level adjustment. The **MO-160** has a built-in variable attenuator of 25 to 30 dB, programmed in 33 steps of 1 dB aproximately. At the same time, the nominal RF level can be finely adjusted using a voltage controlled attenuator. This allows to set a reference level using the voltage controlled attenuator, to then apply the mentioned 1 dB attenuation steps approximately to that reference value.

That RF gain structure can be controlled using the following functions.

- **Attenuation**: this function allows to select the RF output level by applying 1 dB attenuation steps approximately, from 0 dB to 30 dB. Turning the encoder CW increases the attenuation, reducing the output level. Turning CCW enables the opposite behaviour.

Level changes are applied immediately to the RF output, to allow smooth and easy adjustment of RF output conditions. Pressing the encoder or MENU key exits this function.

## 4.7 TEST functions

This menu contains a series of parameters used to correctly carry out all types of transmission tests using the **MO-160** modulator.

- **MODE:** Selects the test to be carried out. Available options are:

  **NONE:** Normal COFDM output.

  **CBER:** Inject channel bit errors to obtain a non-zero BER before the Viterbi decoder (Channel BER).

  **VBER:** Inject bit errors to obtain a non-zero BER after the Viterbi decoder (Viterbi BER or simply BER).

  **Blank carriers:** Blank carriers starting at index Start Carrier and ending at index Stop Carrier (see below).

  **Pilots only:** Generate a DVB-T signal containing pilot carriers only (continual and TPS).

  **PRBS/TR 290:** Replace the input to the constellation mapper with a PRBS sequence of length $2^{15}$-1 or $2^{23}$-1(see PBRS bits entry above) as specified in document ETSI TR 101 290.

The following two parameters select the carrier interval to blank, in order to make measurements of intermodulation noise and/or quantisation noise within the channel.

- **Start Carrier**: Selects the initial index (from 0 to 1704 in 2K, 0 to 6816 in 8k) of the first carrier to blank within the COFDM ensemble.

- **Stop Carrier**: Selects the final index (from 0 to 1704 in 2k, 0 to 6816 in 8k) of the last carrier to blank within the COFDM ensemble.

These following two parameters set the amount of errors we inject into the modulator chain:

- **CBER Value**: Channel Bit-Error Ratio to inject at the input of the mapper to constellation points. This yields a non-zero BER before the Viterbi decoder (values from 7.6E-6 to 1.2E-1).

- **VBER Value**: Viterbi BER to inject at the input to the convolutional encoder so that a non-zero BER is obtained at the output of the Viterbi decoder (values from 3.7E-9 to 6.2E-2).

## 4.8 CONFIGURATION functions

Under this menu tree there is a collection of functions related to the configuration and setup of the whole instrument.

- **Save to Memory**: The **MO-160** has a number of configuration memories that allow to store the modulator parameters as well as the RF frequency and level.

To store the current configuration, turn the encoder to select the desired memory number (from 0 to 10). Press the encoder key to confirm the storing action. Press the MENU key to cancel the action.

This function, as well as the recall option explained hereafter, automatically increments the memory number, to allow to easily store and recall the contents of consecutive memories.

- **Load from Memory**: This is the counterpart function of the previous one. Selecting the desired memory number, a complete equipment configuration can be loaded.

- **Channel Plan**: Use this function to choose among the channel plans included in the **MO-160**. Currently, the available channel plans (an ordered list of channel frequencies) have been translated from the standard analogue channel plans. A complete list of all channel plans has been included at the end of this document (see Appendix A).

The selections displayed using the rotary encoder are:

**CCIR** (Main west European standard)
**STD L** (French standard)
**OIRT** (East European standard)
**UHF** (Only the UHF part from CCIR, for faster selection)

- **IF Mode**: By using this function, the user can select generating a COFDM signal or a single tone. A single tone can be useful for accurate alignment or testing of external components. The available options are:

  COFDM: Generate a COFDM DVB-T signal.

  TONE MAX: Generate a single tone at the maximum level available from the MO-160.

  TONE RMS: Generate a single tone at an RMS level equal to the RMS level of the modulated COFDM signal.

- **Error List**: During the continuous operation of the **MO-160**, the first 16 errors detected are stored as a reference to identify problems. Usually, no errors are generated, and the display should be as follows:

  **MENU: back PUSH: select TURN: next/prev.**
  **NO ERRORS**

But, during operation, two different kinds of errors are possible (See section "*4.11 Error information*"):

- Errors generated when the modulator is not locked to the selected TS input.

These are usually temporary errors related to input transport stream transitions or invalid TS bit rates.

- Errors generated due to a circuit failure. When this kind of errors persists, the instrument must be serviced in a **PROMAX** official center.

See section 4.11 for an explanation of the format used to display the errors.

- **Clear Errors**: select this function to clear the internal error counter and errors list explained formerly. The possible selections are:

  NO

  YES

- **Firmware:** Indicates the version firmware included in the equipment. A sample screen looks as follows:

  **MENU: back PUSH: select TURN: next/prev.**
  **CONFIGURATION Firmware: v1.0.02 - 84.00**

English

## 4.9 REMOTE control through RS-232 interface

The **MO-160** has an RS-232C compatible serial port to connect to a computer for remote control. A suitable set of remote control commands allows enquiring and changing any functional parameter.

Communication details: There is a control protocol to synchronize command reception and validation. A command must be sent once an XON (coded 0x11: hexadecimal value 11 or 17 in decimal) character is received from the instrument. When the instrument detects a complete command, it sends an XOFF (0x13) code and, once validated and executed, an ACK (0x06) or NAK (0x15) code is sent to the remote controller.

To ensure error-free communication between the two devices, the communication parameters for the serial port on the remote controller are as follows:

**Rate: 19200 bauds, Data bits: 8 bits, Parity: None, Stop bits: 1**

The **MO-160** accepts remote commands at any time, when the instrument is on. It's not necessary to put the instrument in a special remote control mode. The communication is carried out using the transmitter and receiver data lines on the serial port. Also the control signals CTS and RTS must be connected.

A standard PC computer DB9F to DB9F NULL MODEM serial cable can be used when connecting the instrument to an available COM port.

The communication protocol is as follows:

1) **MO-160** transmits a XON code (0x11) every second. The aim is to indicate to any possible remote device that the equipment is ready to receive data.

2) At this moment, data streams can be sent to it. Each data stream is made of:

   Initial character ':' (code 0x2A)

   Set of characters that describe data message.

   Final character CR (carry return, code 0x0D)

3) Once a data stream has been sent, an XOFF will be received, indicating that the transmission of any new command must wait until completion of the current one.

4) Next, if the message format is correct and its execution has no errors, an ACK (acknowledge) should be expected. Otherwise, an NAK (not acknowledge) will be received.

5) If the sent message requires an answer, it will be sent at this point.

6) Once completed the message processing, the **MO-160** will send an XON indicating that its ready for a new command.

A typical communication timing diagram would be as follows:

| PC | MO-160 |
|---|---|
| 1) ⇐ XON | (equipment ready for command) |
| 2)*?NA<cr> ⇒ | (command issued by the controller) |
| 3) ⇐ XOFF | (command received indication) |
| 4) ⇐ ACK | (command accepted / understood) |
| 5) wait ... | (execution delay) |
| 6) ⇐ *NAMO-160<cr> | (command answer sent) |
| 7) wait ... | (usually some small delay) |
| 8) ⇐ XON | (equipment ready for command) |

(All characters are transmitted in ASCII code)

Commands should always be sent in capital letter and cannot be edited online, i.e., once a character is received it is stored in the **MO-160** buffer and cannot be rectified by sending an erase code.

When in communication idle mode (**MO-160** waiting for a command) the instrument will send an XON code at one second intervals, to allow synchronization.

**Command list**: Commands are classified between interrogative and control commands. They are initiated by sending an '*' character, and have ASCII text format and always share a similar structure. For instance, the equipment model name can be asked by sending "*?NA<cr>" and the answer is "*NAMO-160" (always without quotes) Some amount of parsing must be applied, to recover the wanted data from the answer text (in this case, "MO-160")

Here follows a table with all available commands.

| Name | Message | Answer | Description and Format |
|---|---|---|---|
| **NAM** | *?NAM<cr>⇒ | ⇐*NAMMO-160<cr> | Retrieve equipment model |
| **VER** | *?VER<cr>⇒ | ⇐*VERv0.7.10<cr> | Retrieve SW version. |
| **BEP** | *BEP<cr> | | Acoustic indication |
| **USR** | *USR***text**<cr> | | Set a new USER text to be displayed in the LCD panel.<br>***'text'*** is an ASCII text with a maximum of 32 characters |
| | *?USR<cr> | *USR***text**<cr> | Returns the current USER text |
| **STO** | *STO***nn**<cr> | | Save the current configuration to a memory.<br>´***nn***´ is a decimal value from 00 to 10 |
| **RCL** | *RCL***nn**<cr> | | Retrieve a configuration from a memory.<br>´***nn***´ is a decimal value from 00 to 10 |
| **FRQ** | *FRQ***nn…n**<cr> | | Modify the equipment RF frequency.<br>´***nn…n***´ is the frequency value in Hz, expressed with 9 digits, from 45 to 875 MHz |
| | *?FRQ<cr> | *FRQ***nn…n**<cr> | Returns the current RF frequency in Hz and with 9 digits (padding with '0' on the left). |
| **ATT** | *ATT***nn**<cr> | | Change the RF output attenuation.<br>'**nn**' is the new decimal attenuation value in dB |
| | *?ATT<cr> | *ATT***nn**<cr> | Returns the current RF attenuation value.<br>'***nn***' value using 2 decimal digits<br>(padding with '0' on the left) |
| **ERN** | *?ERN<cr> | *ERN***nn…n**<cr> | Retrieve the internal error counter.<br>***'nn…n'*** value using 8 decimal digits<br>(padding with '0' on the left) |
| **ERC** | *ERC<cr> | | Clear the internal error counter. |
| **ERL** | *?ERL***nn**<cr> | *ERL***text**<cr> | Retrieve an error message<br>'***nn***' is the error index in decimal value ***'text'*** is the text string in ASCII format |
| **LCK** | *?LCK<cr> | * LCK***chhhh** <cr> | Retrieve the locked status.<br>'**c**' is the lock test result: 'L for locked, 'U' for unlocked<br>***'hhhh'*** is an hexadecimal value corresponding to a status code (see section 4.11 for error codes) |
| **MIH** | *MIH**d**<cr> | | Sets the modulator HP TS Input<br>**'d'** decimal digit<br>0:ASI1 1:ASI2 2:SPI 3:TEST |
| | *?MIH<cr> | *MIH**d**<cr> | Asks for the current modulator HP TS input. **'d'** as before |
| **MIL** | *MIL**d**<cr> | | Sets the modulator LP TS input<br>**'d'** decimal digit<br>0:ASI1 1:ASI2 2:SPI 3:TEST |
| | *?MIL<cr> | *MIL**d**<cr> | Asks for the current modulator HP TS input. **'d'** as before |
| **MBW** | *MBW***d**<cr> | | Sets the modulator output BW<br>***'d'*** decimal digit<br>0: 8MHz, 1: 7MHz, 2: 6MHz |
| | *?MBW<cr> | *MBW***d**<cr> | Asks for the current modulator output BW. ***'d'*** as before |

| Name | Message | Answer | Description and Format |
|---|---|---|---|
| **MHI** | *MHI***d**<cr> | | Sets the modulator hierarchy mode.<br>***'d'*** decimal digit<br>0: NO, 1: α=1, 2: α=2, 3: α=4 |
| | *?MHI<cr> | *MHI***d**<cr> | Asks for the current hierarchy mode.***'d'*** as before |
| **MTP** | *MTP**d**<cr> | | Sets the modulator test mode.<br>**'d'** decimal digit<br>0:NONE, 1:CBER, 2:VBER, 3:BlkCar, 4:PILOTS, 5:PRBS |
| | *?MTP<cr> | *MTP**d**<cr> | Asks for the current test mode.<br>**'d'** as before |
| **HCR** | *HCR***d**<cr> | | Sets the modulator TS high priority code rate.<br>***'d'*** decimal digit<br>0:1/2 1:2/3, 2:3/4, 3:5/6, 4:7/8 |
| | *?HCR<cr> | *HCR***d**<cr> | Asks for the current CR for the high priority TS.<br>***'d'*** as before |
| **LCR** | *LCR***d**<cr> | | Sets the modulator TS low priority code rate.<br>***'d'*** decimal digit<br>0:1/2 1:2/3, 2:3/4, 3:5/6, 4:7/8 |
| | *?LCR<cr> | *LCR***d**<cr> | Asks for the current CR for the low priority TS.<br>***'d'*** as before |
| **MCO** | *MCO***d**<cr> | | Sets the modulator constellation.<br>***'d'*** decimal digit<br>0:QPSK, 1:16QAM, 2:64QAM |
| | *?MCO<cr> | *MCO***d**<cr> | Asks for the current modulator constellation. ***'d'*** as before |
| **MGU** | *MGU***d**<cr> | | Sets the modulator guard interval.. ***'d'*** decimal digit 0:1/4, 1:1/8, 2:1/16, 3:1/32. |
| | *?MGU<cr> | *MGU***d**<cr> | Asks for the current modulator guard interval.<br>***'d'*** as before |
| **FFT** | *FFT***d**<cr> | | Sets the modulator FFT mode.<br>***'d'*** decimal digit 0: 2K, 1: 8K |
| | *?FFT<cr> | *FFT***d**<cr> | Asks for the current modulator FFT mode.<br>***'d'*** as before |
| **INV** | *INV***d**<cr> | | Sets the modulator spectral inversion mode.<br>***'d'*** decimal digit 0:INV, 1:NO INV |
| | *?INV<cr> | *INV***d**<cr> | Asks for the current modulator spectral inversion mode. ***'d'*** as before |
| **MOD** | *MOD***d**<cr> | | Sets the modulator IF output mode.<br>***'d'*** decimal digit<br>0: COFDM, 1: TONE MAX, 2: TONE RMS |
| | *?MOD<cr> | *MOD***d**<cr> | Asks for the current modulator IF output mode.<br>***'d'*** as before |
| **FIF** | *FIF***nn…n**<cr> | | Modify the equipment IF frequency. ´***nn…n***´ is the frequency value in Hz, expressed with 8 digits, from 31 to 37 MHz |
| | *?FIF<cr> | *FIF***nn…n**<cr> | Returns the current IF frequency in Hz expressed with 8 digits (padding with '0' on the left) |
| **DIS** | *DIS***d**<cr> | | Disable the RF output.<br>***'d'*** decimal digit<br>0:ENABLE RF, 1:DISABLE RF |
| | *?DIS<cr> | *DIS***d**<cr> | Asks for the current RF disable state.<br>***'d'*** as before. |
| **MPR** | *MPR**d**<cr> | | PRBS of 15 or 23 bits<br>**'d'** decimal digit<br>0:15 bits PRBS 1:23 bits PRBS |
| | *?MPR<cr> | *MPR**d**<cr> | Asks for the current PRBS length with **'d'** as before |

English

| Name | Message | Answer | Description and Format |
|---|---|---|---|
| **MRE** | *MRE**d**<cr> | | PCR restamping (master mode) ON/OFF.<br>**'d'** decimal digit<br>0: ON 1: OFF |
| | *?MRE<cr> | *MRE**d**<cr> | Asks for the current restamping state. **'d'** as before |
| **MTS** | *MTS**d**<cr> | | TS lock mode MASTER or SLAVE<br>**'d'** decimal digit<br>0:SLAVE 1:MASTER |
| | *?MTS<cr> | *MTS**d**<cr> | Asks for the current TS lock mode. **'d'** as before |
| **MSS** | *MSS**d**<cr> | | Active TS in SLAVE mode<br>**'d'** decimal digit<br>0:HP 1:LP |
| | *?MSS<cr> | *MSS**d**<cr> | Asks for the Active TS in SLAVE mode. **'d'** as before |
| **MPL** | *?MPL<cr> | *MPLhhh/lll <cr> or<br>*MPLhhh <cr> | Asks for the TS packet length detected<br>**'hhh' & 'lll'** ASCII text<br>hhh,lll: 188 or 204 bytes for HP/LP TS (LP in hierarchical mode only) |
| **MII** | *MII**dddd**<cr> | | Initial carrier index for the blank carriers test mode.<br>**'dddd'** decimal digits<br>(0000 to 6816 @ 8k, 1604 @ 2k) |
| | *?MII<cr> | *MIIdddd<cr> | Asks for the initial carrier index value. **'dddd'** as before |
| **MFI** | *MFI**dddd**<cr> | | Final carrier index for the blank carriers test mode.<br>**'dddd'** decimal digits<br>(0000 a 6816 @ 8k, 1604 @ 2k) |
| | *?MFI<cr> | *MFI**dddd**<cr> | Asks for the final carrier index value. **'dddd'** as before |
| **MCB** | *MCB**ddddddd**<cr> | | CBER value generated in test mode.<br>**'ddddddd'** decimal digits<br>**ddddddd** = CBER x 1E7 |
| | *?MCB<cr> | *MCB**ddddddd**<cr> | Asks for the current CBER value.<br>**'ddddddd'** as before |
| **MVB** | *MVB**ddddddddddd**<cr> | | VBER value generated in test mode.<br>**'ddddddddddd'** decimal digits<br>**ddddddddddd** = VBER x 1E10 |
| | *?MVB<cr> | *MVB**ddddddddddd**<cr> | Asks for the current VBER value.<br>**'ddddddddddd'** as before |

## 4.10 DVB-T useful bit rates

In the following, we present the useful bit rates (Mbits/s or Mbps) for all combinations of guard interval, constellation and convolutional code rates in **DVB-T** systems and channels of 8, 7 and 6 MHz bandwidths. The useful bit rate does not depend on the transmission mode (2k or 8k).

These tables are similar to Tables 17 (8 MHz), E.6 (7 MHz) and E.3 (6 MHz) in document ETSI EN 300 744 v 1.5.1 (2004-11), but with 7 digits of accuracy instead of 2 or 3. This additional accuracy is necessary since the bit rate of the input transport streams when operating in slave mode should not deviate more them a 0.1‰ from the values shown herein, otherwise the MO-160 will not lock. For example, for **QPSK**, code ½ and guard interval of 1/4, the useful bit rate of **DVB-T** systems for 8 MHz bandwidth channels is 4.9764706 Mbps, thus in slave mode the TS input bit rate to which the modulator is able to sync should be greater than 4.975973 Mbps and lesser than 4.976968 Mbps.

| Constellation | Convolutional code | Guard interval | | | |
|---|---|---|---|---|---|
| | | 1/4 | 1/8 | 1/16 | 1/32 |
| QPSK | 1/2 | 4,9764706 | 5,5294118 | 5,8546713 | 6,0320856 |
| | 2/3 | 6,6352941 | 7,3725490 | 7,8062284 | 8,0427807 |
| | 3/4 | 7,4647059 | 8,2941176 | 8,7820069 | 9,0481283 |
| | 5/6 | 8,2941176 | 9,2156863 | 9,7577855 | 10,0534759 |
| | 7/8 | 8,7088235 | 9,6764706 | 10,2456747 | 10,5561497 |
| 16QAM | 1/2 | 9,9529412 | 11,0588235 | 11,7093426 | 12,0641711 |
| | 2/3 | 13,2705882 | 14,7450980 | 15,6124567 | 16,0855615 |
| | 3/4 | 14,9294118 | 16,5882353 | 17,5640138 | 18,0962567 |
| | 5/6 | 16,5882353 | 18,4313725 | 19,5155709 | 20,1069519 |
| | 7/8 | 17,4176471 | 19,3529412 | 20,4913495 | 21,1122995 |
| 64QAM | 1/2 | 14,9294118 | 16,5882353 | 17,5640138 | 18,0962567 |
| | 2/3 | 19,9058824 | 22,1176471 | 23,4186851 | 24,1283422 |
| | 3/4 | 22,3941176 | 24,8823529 | 26,3460208 | 27,1443850 |
| | 5/6 | 24,8823529 | 27,6470588 | 29,2733564 | 30,1604278 |
| | 7/8 | 26,1264706 | 29,0294118 | 30,7370242 | 31,6684492 |

**Table 1.-** Useful bit rate (Mbps) for DVB-T modes and 8 MHz channel bandwidths.

For hierarchical modulations with an 8 MHz bandwidth, the useful bit rates can be obtained from Table 1 following these indications:

- Sequence of high priority (HP): QPSK values
- Sequence of low priority (LP), 16QAM: QPSK values
- Sequence LP, 64QAM: 16QAM values

| Constellation | Convolutional code | Guard interval | | | |
|---|---|---|---|---|---|
| | | 1/4 | 1/8 | 1/16 | 1/32 |
| QPSK | 1/2 | 4,3544118 | 4,8382353 | 5,1228374 | 5,2780749 |
| | 2/3 | 5,8058824 | 6,4509804 | 6,8304498 | 7,0374332 |
| | 3/4 | 6,5316176 | 7,2573529 | 7,6842561 | 7,9171123 |
| | 5/6 | 7,2573529 | 8,0637255 | 8,5380623 | 8,7967914 |
| | 7/8 | 7,6202206 | 8,4669118 | 8,9649654 | 9,2366310 |
| 16QAM | 1/2 | 8,7088235 | 9,6764706 | 10,2456747 | 10,5561497 |
| | 2/3 | 11,6117647 | 12,9019608 | 13,6608997 | 14,0748663 |
| | 3/4 | 13,0632353 | 14,5147059 | 15,3685121 | 15,8342246 |
| | 5/6 | 14,5147059 | 16,1274510 | 17,0761246 | 17,5935829 |
| | 7/8 | 15,2404412 | 16,9338235 | 17,9299308 | 18,4732620 |
| 64QAM | 1/2 | 13,0632353 | 14,5147059 | 15,3685121 | 15,8342246 |
| | 2/3 | 17,4176471 | 19,3529412 | 20,4913495 | 21,1122995 |
| | 3/4 | 19,5948529 | 21,7720588 | 23,0527682 | 23,7513369 |
| | 5/6 | 21,7720588 | 24,1911765 | 25,6141869 | 26,3903743 |
| | 7/8 | 22,8606618 | 25,4007353 | 26,8948962 | 27,7098930 |

**Table 2.-** Useful bit rate (Mbps) for DVB-T modes and 7 MHz channel bandwidths.

For hierarchical modulations, you must follow the guidelines shown below Table 1.

| Constellation | Convolutional code | Guard interval | | | |
|---|---|---|---|---|---|
| | | 1/4 | 1/8 | 1/16 | 1/32 |
| QPSK | 1/2 | 3,7323529 | 4,1470588 | 4,3910035 | 4,5240642 |
| | 2/3 | 4,9764706 | 5,5294118 | 5,8546713 | 6,0320856 |
| | 3/4 | 5,5985294 | 6,2205882 | 6,5865052 | 6,7860963 |
| | 5/6 | 6,2205882 | 6,9117647 | 7,3183391 | 7,5401070 |
| | 7/8 | 6,5316176 | 7,2573529 | 7,6842561 | 7,9171123 |
| 16QAM | 1/2 | 7,4647059 | 8,2941176 | 8,7820069 | 9,0481283 |
| | 2/3 | 9,9529412 | 11,0588235 | 11,7093426 | 12,0641711 |
| | 3/4 | 11,1970588 | 12,4411765 | 13,1730104 | 13,5721925 |
| | 5/6 | 12,4411765 | 13,8235294 | 14,6366782 | 15,0802139 |
| | 7/8 | 13,0632353 | 14,5147059 | 15,3685121 | 15,8342246 |
| 64QAM | 1/2 | 11,1970588 | 12,4411765 | 13,1730104 | 13,5721925 |
| | 2/3 | 14,9294118 | 16,5882353 | 17,5640138 | 18,0962567 |
| | 3/4 | 16,7955882 | 18,6617647 | 19,7595156 | 20,3582888 |
| | 5/6 | 18,6617647 | 20,7352941 | 21,9550173 | 22,6203209 |
| | 7/8 | 19,5948529 | 21,7720588 | 23,0527682 | 23,7513369 |

**Table 3.-** Useful bit rate (Mbps) for DVB-T modes and 6 MHz channel bandwidths.

For hierarchical modulations, you must follow the guidelines shown below Table 1.

## 4.11 Error Information

When using the equipment, operating errors can occur as well as errors related to the loss of synchronization in the **MPEG-2** input transport stream.

The first 16 errors appearing during the instrument operation are internally registered and can be retrieved or erased by means of the functions in **CONFIGURATION** menu.

This section describes the error list display format and the meaning of the codes that appear in each case for each type of error.

### 4.11.1 Types of errors

The control program of the **MO-160** can detect and show up to 4 types of errors. Some of them correspond to instrument malfunction and must be directly reported to a PROMAX's Customers Service Centre (CSC). Others state incorrect options about modulator input signals.

1. **NAK**: An internal device connected to control $I^2C$ bus does not respond to the messages from the microcontroller. It requires service of CSC.
2. **UNKN**: Unknown error. Due to a problem different to the one previously described, the $I^2C$ control system cannot be accessed. It requires service of CSC.
3. **BUSY**: The $I^2C$ bus controller is busy and has not been possible to recover its operation. It requires service of CSC.
4. **MOD FAIL**: It covers all errors corresponding to the MPEG-2 transport stream inputs not being correctly synchronized and/or not having the right bit rate.

### 4.11.2 Error Coding

**NAK**, **BUSY** and **UNKN** are for internal use of Promax. If any of these errors occurs repeatedly, the equipment ought to be taken to a PROMAX's customer service centre for repair.

**MOD FAIL**: The display format for this type of errors is as follows:

**ERR02 MOD FAIL STATUS: XXYY (CCC…C)**

When this type of errors occur, the **MO-160** presents an error message on the LCD display starting with the word STATUS and followed by an explanation of the type of error (e.g. HP TS SYNC LOST, LP TS BUFFER FULL or INVALID TS RATE). Needless to say, in this scenario the ERROR LED flashes red for 5 seconds, and then stays lit until the error count is cleared within the CONFIGURATION menu.

The numerical fields have the following meaning:

**XX:** Hexadecimal value composed by several information bits, with meaning according to the modulator configuration. Eight bits compose the data structure. Each bit marks an error status when its value is "1", except when the opposite is indicated:

**b7 b6 b5 b4 b3 b2 b1 b0**

Bits **b7** and **b6** are always "0".

Bits **b5** to **b2** have meaning if the equipment is working in MASTER mode. They indicate the state of synchronisation of the modulator with the MPEG-2 input TS (HP or LP), as follows:

**b5:** HP TS buffer full. The input TS bit rate is above the maximum value. You must reduce the transport stream bit rate. If the hierarchical mode is activated, this error refers to the high priority TS (HP TS).

**b4:** LP TS buffer full. The input TS bit rate is above the maximum value. You must reduce the transport stream bit rate. If the hierarchical mode is activated, this error refers to the low priority TS (LP TS).

**b3:** HP TS sync lost. The synchronisation with the input TS has been lost. The most probable cause is that an input transport stream is not available or that it has been temporally disconnected. If the hierarchical mode is on, this error refers to the high priority TS (HP TS).

**b2:** LP TS sync lost. The synchronisation with the input TS has been lost. The most probable cause is that an input transport stream is not available or that it has been temporally disconnected. If the hierarchical mode is on, this error refers to the low priority TS (LP TS).

Bits **b1** to **b0** have meaning if the equipment is in SLAVE mode. If we are in hierarchical mode, the information applies to the TS selected for synchronisation (HP or LP). In non-hierarchical modes, we refer to the main TS. The meaning of each bit is as follows:

**b1:** TS sync lost. The synchronisation with the input TS has been lost. The most probable cause is that an input transport stream is not available or that it has been temporally disconnected.

**b0:** Valid TS rate. **This bit is erroneous when its value is "0"**. The data rate at the TS input is either too high or too low for the DVB-T configuration being used. Recall that this bit rate should be within ±0.1‰ of the values shown in the Tables of section 4.10.

Therefore, if the hex **XX** value shown is, for example, 0x24, and we are in MASTER mode in any of the hierarchical modes, we must split the binary code and analyse each bit separately in order to determine the type of failure:

| HEX | b7 | b6 | **b5** | **b4** | **b3** | **b2** | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| 24 | 0 | 0 | **1** | **0** | **0** | **1** | 0 | 0 |

English

In this case, bits **b5** and **b2** have been asserted, indicating that there are two types of errors:

| | |
|---|---|
| **b5** | The bit rate of the selected HP TS input is too high. |
| **b2** | Loss of synchronization with selected LP TS input |

**YY:** This complementary information is also expressed in hexadecimal. The value of each bit indicates a possible anomaly in the operation of the circuit. In all cases, a deviation with respect to the value of reference indicates a failure in some of the circuits that compose the modulator. Contact technical assistance (CSC) for repair.

The value of reference (all OK) is **1B**, which corresponds to the following value of each bit:

| HEX | b7 | b6 | **b5** | **b4** | **b3** | **b2** | b1 | **b0** |
|---|---|---|---|---|---|---|---|---|
| 1B | 0 | 0 | **0** | **1** | **1** | **0** | 1 | **1** |

Bits **b7** and **b6** are always "0". Bit **b1** is always "1".

A change in bits **b5**, **b4** or **b3**, indicates failure in the **IF** generation circuitry (Digital to Analogue converter).

A change in bits **b2** or **b0** implies failure in the COFDM DVB-T modulator circuitry.

**CCC… C**: This parameter is a global error counter. It counts the **number of errors at the moment in which the error message is displayed**. Therefore, if an error of any type occurs continuously, this counter will have a different value whenever we look at some of the first 16 errors detected by the equipment.

In relation to this value, it must be noted that, in order to detect an error (for example the loss of synchronization with a TS input), the equipment waits for this situation to occur for more than 5 seconds. So, it avoids errors in the transitions between different modulator functions or temporary TS input disconnections to be counted.

However, the total error counter (**CCC… C**) does count each occurrence, regardless of whether or not it lasts more than 5 seconds.

# 5 MAINTENANCE

## 5.1 Mains fuse replacement

The fuseholder is located on the later panel of the equipment.

Before replacing the fuse disconnect the mains cord.

Take out the fuse holder with screwdriver. Replace the fuse damaged by a suitable new one and place afresh the fuseholder.

**Fuse 5x20 2A T 250V**

**THE BREACH OF THESE INSTRUCTIONS COULD DAMAGE THE EQUIPMENT**

## 5.2 Cleaning Recommendations

***CAUTION***

*To clean the cover, take care the instrument is disconnected.*

***CAUTION***

*Do not use scented hydrocarbons or chlorized solvents. Such products may attack the materials used in the construction of the cover.*

The cover should be cleaned by means of a light solution of detergent and water applied with a soft cloth.

Dry thoroughly before using the system again.

***CAUTION***

Do not use for the cleaning of the front panel, alcohol or its derivatives. These products can attack the mechanical properties of the materials and diminish their useful time of life.

English

# APÉNDICE A: Listas de Canales
# *APPENDIX A: Channel Plans*

## Lista de canales CCIR
## CCIR channel plan

| CHANNEL | FREQ | CHANNEL | FREQ | CHANNEL | FREQ |
|---|---|---|---|---|---|
| E02 | 50500000 Hz | S24 | 330000000 Hz | C37 | 602000000 Hz |
| E03 | 57500000 Hz | S25 | 338000000 Hz | C38 | 610000000 Hz |
| E04 | 64500000 Hz | S26 | 346000000 Hz | C39 | 618000000 Hz |
| S01 | 107500000 Hz | S27 | 354000000 Hz | C40 | 626000000 Hz |
| S02 | 114500000 Hz | S28 | 362000000 Hz | C41 | 634000000 Hz |
| S03 | 121500000 Hz | S29 | 370000000 Hz | C42 | 642000000 Hz |
| S04 | 128500000 Hz | S30 | 378000000 Hz | C43 | 650000000 Hz |
| S05 | 135500000 Hz | S31 | 386000000 Hz | C44 | 658000000 Hz |
| S06 | 142500000 Hz | S32 | 394000000 Hz | C45 | 666000000 Hz |
| S07 | 149500000 Hz | S33 | 402000000 Hz | C46 | 674000000 Hz |
| S08 | 156500000 Hz | S34 | 410000000 Hz | C47 | 682000000 Hz |
| S09 | 163500000 Hz | S35 | 418000000 Hz | C48 | 690000000 Hz |
| S10 | 170500000 Hz | S36 | 426000000 Hz | C49 | 698000000 Hz |
| E05 | 177500000 Hz | S37 | 434000000 Hz | C50 | 706000000 Hz |
| E06 | 184500000 Hz | S38 | 442000000 Hz | C51 | 714000000 Hz |
| E07 | 191500000 Hz | S39 | 450000000 Hz | C52 | 722000000 Hz |
| E08 | 198500000 Hz | S40 | 458000000 Hz | C53 | 730000000 Hz |
| E09 | 205500000 Hz | S41 | 466000000 Hz | C54 | 738000000 Hz |
| E10 | 212500000 Hz | C21 | 474000000 Hz | C55 | 746000000 Hz |
| E11 | 219500000 Hz | C22 | 482000000 Hz | C56 | 754000000 Hz |
| E12 | 226500000 Hz | C23 | 490000000 Hz | C57 | 762000000 Hz |
| S11 | 233500000 Hz | C24 | 498000000 Hz | C58 | 770000000 Hz |
| S12 | 240500000 Hz | C25 | 506000000 Hz | C59 | 778000000 Hz |
| S13 | 247500000 Hz | C26 | 514000000 Hz | C60 | 786000000 Hz |
| S14 | 254500000 Hz | C27 | 522000000 Hz | C61 | 794000000 Hz |
| S15 | 261500000 Hz | C28 | 530000000 Hz | C62 | 802000000 Hz |
| S16 | 268500000 Hz | C29 | 538000000 Hz | C63 | 810000000 Hz |
| S17 | 275500000 Hz | C30 | 546000000 Hz | C64 | 818000000 Hz |
| S18 | 282500000 Hz | C31 | 554000000 Hz | C65 | 826000000 Hz |
| S19 | 289500000 Hz | C32 | 562000000 Hz | C66 | 834000000 Hz |
| S20 | 296500000 Hz | C33 | 570000000 Hz | C67 | 842000000 Hz |
| S21 | 306000000 Hz | C34 | 578000000 Hz | C68 | 850000000 Hz |
| S22 | 314000000 Hz | C35 | 586000000 Hz | C69 | 858000000 Hz |
| S23 | 322000000 Hz | C36 | 594000000 Hz | | |

**Lista de canales OIRT**
**OIRT channel plan**

| CHANNEL | FREQ | CHANNEL | FREQ | CHANNEL | FREQ |
|---|---|---|---|---|---|
| I | 52500000 Hz | C30 | 546000000 Hz | C51 | 714000000 Hz |
| II | 62000000 Hz | C31 | 554000000 Hz | C52 | 722000000 Hz |
| III | 80000000 Hz | C32 | 562000000 Hz | C53 | 730000000 Hz |
| IV | 88000000 Hz | C33 | 570000000 Hz | C54 | 738000000 Hz |
| V | 96000000 Hz | C34 | 578000000 Hz | C55 | 746000000 Hz |
| VI | 178000000 Hz | C35 | 586000000 Hz | C56 | 754000000 Hz |
| VII | 186000000 Hz | C36 | 594000000 Hz | C57 | 762000000 Hz |
| VIII | 194000000 Hz | C37 | 602000000 Hz | C58 | 770000000 Hz |
| IX | 202000000 Hz | C38 | 610000000 Hz | C59 | 778000000 Hz |
| X | 210000000 Hz | C39 | 618000000 Hz | C60 | 786000000 Hz |
| XI | 218000000 Hz | C40 | 626000000 Hz | C61 | 794000000 Hz |
| XII | 226000000 Hz | C41 | 634000000 Hz | C62 | 802000000 Hz |
| C21 | 474000000 Hz | C42 | 642000000 Hz | C63 | 810000000 Hz |
| C22 | 482000000 Hz | C43 | 650000000 Hz | C64 | 818000000 Hz |
| C23 | 490000000 Hz | C44 | 658000000 Hz | C65 | 826000000 Hz |
| C24 | 498000000 Hz | C45 | 666000000 Hz | C66 | 834000000 Hz |
| C25 | 506000000 Hz | C46 | 674000000 Hz | C67 | 842000000 Hz |
| C26 | 514000000 Hz | C47 | 682000000 Hz | C68 | 850000000 Hz |
| C27 | 522000000 Hz | C48 | 690000000 Hz | C69 | 858000000 Hz |
| C28 | 530000000 Hz | C49 | 698000000 Hz | | |
| C29 | 538000000 Hz | C50 | 706000000 Hz | | |

**Lista de canales UHF**
**UHF channel plan**

| CHANNEL | FREQ | CHANNEL | FREQ | CHANNEL | FREQ |
|---|---|---|---|---|---|
| C21 | 474000000 Hz | C38 | 610000000 Hz | C55 | 746000000 Hz |
| C22 | 482000000 Hz | C39 | 618000000 Hz | C56 | 754000000 Hz |
| C23 | 490000000 Hz | C40 | 626000000 Hz | C57 | 762000000 Hz |
| C24 | 498000000 Hz | C41 | 634000000 Hz | C58 | 770000000 Hz |
| C25 | 506000000 Hz | C42 | 642000000 Hz | C59 | 778000000 Hz |
| C26 | 514000000 Hz | C43 | 650000000 Hz | C60 | 786000000 Hz |
| C27 | 522000000 Hz | C44 | 658000000 Hz | C61 | 794000000 Hz |
| C28 | 530000000 Hz | C45 | 666000000 Hz | C62 | 802000000 Hz |
| C29 | 538000000 Hz | C46 | 674000000 Hz | C63 | 810000000 Hz |
| C30 | 546000000 Hz | C47 | 682000000 Hz | C64 | 818000000 Hz |
| C31 | 554000000 Hz | C48 | 690000000 Hz | C65 | 826000000 Hz |
| C32 | 562000000 Hz | C49 | 698000000 Hz | C66 | 834000000 Hz |
| C33 | 570000000 Hz | C50 | 706000000 Hz | C67 | 842000000 Hz |
| C34 | 578000000 Hz | C51 | 714000000 Hz | C68 | 850000000 Hz |
| C35 | 586000000 Hz | C52 | 722000000 Hz | C69 | 858000000 Hz |
| C36 | 594000000 Hz | C53 | 730000000 Hz | | |
| C37 | 602000000 Hz | C54 | 738000000 Hz | | |

**Lista de canales STDL**
**STDL channel plan**

| CHANNEL | FREQ | CHANNEL | FREQ | CHANNEL | FREQ |
|---|---|---|---|---|---|
| FA | 50000000 Hz | C22 | 482000000 Hz | C46 | 674000000 Hz |
| FB | 58000000 Hz | C23 | 490000000 Hz | C47 | 682000000 Hz |
| FC1 | 62750000 Hz | C24 | 498000000 Hz | C48 | 690000000 Hz |
| FC | 66000000 Hz | C25 | 506000000 Hz | C49 | 698000000 Hz |
| C05 | 178750000 Hz | C26 | 514000000 Hz | C50 | 706000000 Hz |
| C06 | 186750000 Hz | C27 | 522000000 Hz | C51 | 714000000 Hz |
| C07 | 194750000 Hz | C28 | 530000000 Hz | C52 | 722000000 Hz |
| C08 | 202750000 Hz | C29 | 538000000 Hz | C53 | 730000000 Hz |
| C09 | 210750000 Hz | C30 | 546000000 Hz | C54 | 738000000 Hz |
| C10 | 218750000 Hz | C31 | 554000000 Hz | C55 | 746000000 Hz |
| C11 | 226750000 Hz | C32 | 562000000 Hz | C56 | 754000000 Hz |
| C12 | 234750000 Hz | C33 | 570000000 Hz | C57 | 762000000 Hz |
| C13 | 242750000 Hz | C34 | 578000000 Hz | C58 | 770000000 Hz |
| C14 | 290750000 Hz | C35 | 586000000 Hz | C59 | 778000000 Hz |
| D01 | 306000000 Hz | C36 | 594000000 Hz | C60 | 786000000 Hz |
| D02 | 318000000 Hz | C37 | 602000000 Hz | C61 | 794000000 Hz |
| D03 | 330000000 Hz | C38 | 610000000 Hz | C62 | 802000000 Hz |
| D04 | 342000000 Hz | C39 | 618000000 Hz | C63 | 810000000 Hz |
| D05 | 354000000 Hz | C40 | 626000000 Hz | C64 | 818000000 Hz |
| D06 | 366000000 Hz | C41 | 634000000 Hz | C65 | 826000000 Hz |
| D07 | 378000000 Hz | C42 | 642000000 Hz | C66 | 834000000 Hz |
| D08 | 390000000 Hz | C43 | 650000000 Hz | C67 | 842000000 Hz |
| D09 | 402000000 Hz | C44 | 658000000 Hz | C68 | 850000000 Hz |
| C21 | 474000000 Hz | C45 | 666000000 Hz | C69 | 858000000 Hz |